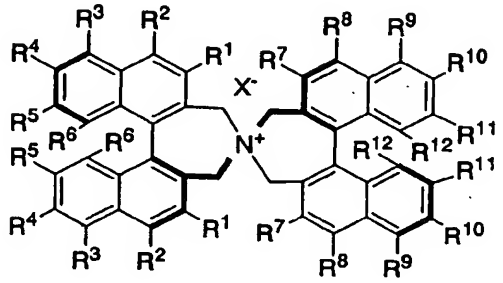
CLAIMS

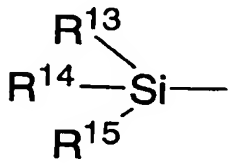
1. An optically active quaternary ammonium salt, represented by the following formula (1a):



(1a)

[wherein R^1, R^2, R^3, R^4, R^5, R^6, R^7, R^8, R^9, R^{10}, R^{11}, and R^{12} are each independently a hydrogen atom, a methyl group, an ethyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic heteroalkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 35 carbon atoms, or a heteroaralkyl group having 5 to 35 carbon atoms;

with the proviso that at least one of R^1, R^2, R^3, R^4, R^5, R^6, R^7, R^8, R^9, R^{10}, R^{11}, and R^{12} is a substituent represented by the following formula (2a):



(2a)

(wherein R^{13}, R^{14}, and R^{15} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms.);

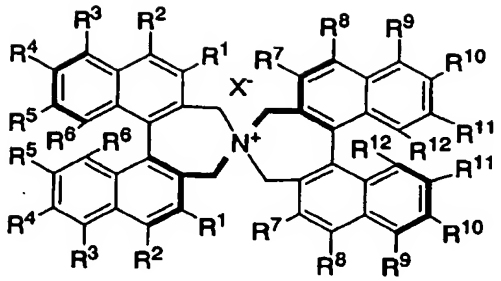
X^- is a fluorine ion, a chloride ion, a bromide ion, an iodide ion, a p-toluenesulfonic acid ion, a hydroxide ion, a thiocyanate ion, a hydrogen sulfate ion, a perchloric acid ion, or a hexafluorophosphoric acid ion; and the two binaphthyl moieties each have a chiral axis so that the absolute configurations of the two binaphthyl moieties are (R, R) or (S, S)].

2. The optically active quaternary ammonium salt according to claim 1, wherein R^1 and R^7, R^3 and R^9, R^4 and R^{10}, R^5 and R^{11}, and R^6 and R^{12} in the formula (1a) are in each case identical to one another; R^2 and R^8 are identical to one another and are each represented by the formula (2a); and X^- is a fluorine ion, a chloride ion, a bromide ion, an iodide ion, a p-toluenesulfonic acid ion, or a hydroxide ion.

3. The optically active quaternary ammonium salt according to claim 1, wherein R^1, R^3, R^5, R^6, R^7, R^9, R^{11}, and R^{12} in the formula (1a) are each independently a hydrogen atom; R^2, R^4, R^8, and R^{10} are identical to one another and are each represented by the formula (2a); and X^- is a chloride ion, a bromide ion, an iodide ion, or a p-toluenesulfonic acid ion.

4. The optically active quaternary ammonium salt according to claim 1, wherein in the formula (1a), R^1 and R^7, R^3 and R^9, R^4 and R^{10}, R^5 and R^{11}, and R^6 and R^{12} are in each case identical to one another, R^2 and R^8 are identical to one another and are each represented by the formula (2a), and X^- is a bromide ion; and R^{13}, R^{14} and R^{15} in the formula (2a) are each independently a substituent selected from the group consisting of a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-octyl group, and a phenyl group.

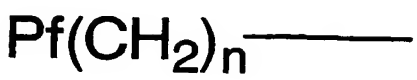
5. An optically active quaternary ammonium salt represented by the following formula (1b):



(1 b)

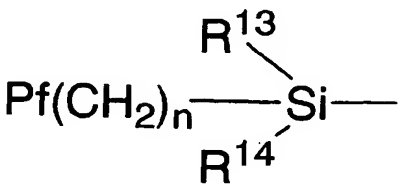
[wherein R^1, R^2, R^3, R^4, R^5, R^6, R^7, R^8, R^9, R^{10}, R^{11}, and R^{12} are each independently a hydrogen atom, a halogen atom, a methyl group that may or may not be substituted with fluorine, an ethyl group that may or may not be substituted with fluorine, a straight, branched or cyclic alkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic heteroalkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, an alkoxyl group that has 1 to 18 carbon atoms and may or may not be substituted with fluorine, an aryl group that has 5 to 20 carbon atoms and may or may not be substituted with fluorine, an aralkyl group that has 5 to 35 carbon atoms and may or may not be substituted with fluorine, or a heteroaralkyl group that has 5 to 35 carbon atoms and may or may not be substituted with fluorine;

with the proviso that at least one of R^1, R^2, R^3, R^4, R^5, R^6, R^7, R^8, R^9, R^{10}, R^{11}, and R^{12} is a substituent represented by the following formula (2b):



(2b)

(wherein Pf is a straight, branched or cyclic alkyl group that has 2 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aryl group that has 5 to 20 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, or a heteroaralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, and n is an integer from 0 to 4.), and/or by the following formula (2c):



(2c)

(wherein Pf and n are as defined in the formula (2b) above, R^{13}

and R^{14} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms.);

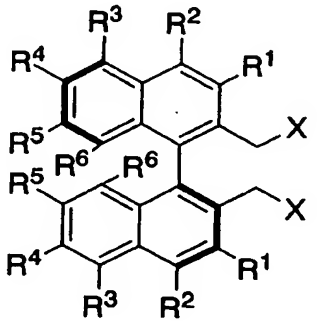
X^- is a fluoride ion, a chloride ion, a bromide ion, an iodide ion, a p-toluenesulfonic acid ion, a hydroxide ion, a thiocyanate ion, a hydrogen sulfate ion, a perchloric acid ion, or a hexafluorophosphoric acid ion; and the two binaphthyl moieties each have a chiral axis so that the absolute configurations of the two binaphthyl moieties are (R, R) or (S, S)].

6. The optically active quaternary ammonium salt according to claim 5, wherein R^1 and R^7, R^3 and R^9, R^4 and R^{10}, R^5 and R^{11}, and R^6 and R^{12} in the formula (1b) are in each case identical to one another; R^2 and R^8 are identical to one another and are each represented by the formula (2a); and X^- is a fluorine ion, a chloride ion, a bromide ion, an iodide ion, a p-toluenesulfonic acid ion, a thiocyanate ion, a hydrogen sulfate ion, or a hydroxide ion.

7. The optically active quaternary ammonium salt according to claim 5, wherein R^1, R^3, R^5, R^6, R^7, R^9, R^{11}, and R^{12} in the formula (1b) are each independently a hydrogen atom; R^2, R^4, R^8, and R^{10} are identical to one another and are each represented by the formula (2c); and X^- is a chloride ion, a bromide ion, an iodide ion, or a p-toluenesulfonic acid ion.

8. The optically active quaternary ammonium salt according to claim 5, wherein in the formula (1b), R^1 and R^7, R^3 and R^9, R^4 and R^{10}, R^5 and R^{11}, and R^6 and R^{12} are in each case identical to one another, and X^- is a bromide ion; and in the formula (2c), n is 2, R^{13} and R^{14} are each a methyl group, and Pf is an n-octyl group having all the hydrogen atoms substituted with fluorine atoms.

9. An optically active binaphthyl compound represented by the following formula (3a):

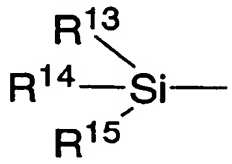


(3a)

[wherein R^1, R^2, R^3, R^4, R^5, and R^6 are each independently a

hydrogen atom, a methyl group, an ethyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic heteroalkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 35 carbon atoms, or a heteroaralkyl group having 5 to 35 carbon atoms;

with the proviso that at least one of R^1, R^2, R^3, R^4, R^5, and R^6 is a substituent represented by the following formula (2a):



(2a)

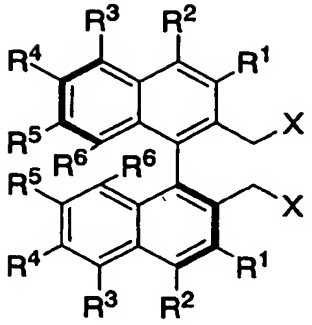
(wherein R^{13}, R^{14}, and R^{15} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms); X is a chlorine atom, a bromine atom, an

iodine atom, or a p-toluenesulfonyloxy group; and the binaphthyl moiety has a chiral axis so that the absolute configuration of the binaphthyl moiety is (R) or (S)].

10. The optically active binaphthyl compound according to claim 9, wherein R^1, R^3, R^5, and R^6 in the formula (3a) are each independently a hydrogen atom; and R^2 and R^4 are identical to one another and are each represented by the formula (2a).

11. The optically active binaphthyl compound according to claim 9, wherein in the formula (3a), R^1, R^3, R^5, and R^6 are each independently a hydrogen atom, R^2 and R^4 are identical to one another and are each represented by the formula (2a), and X is a bromine atom; and R^{13}, R^{14}, and R^{15} in the formula (2a) are each independently a substituent selected from the group consisting of a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-octyl group, and a phenyl group.

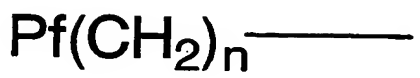
12. An optically active binaphthyl compound represented by the following formula (3b):



(3 b)

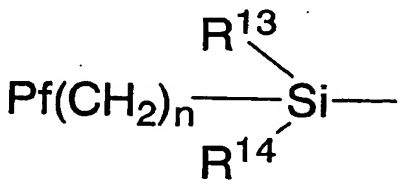
[wherein R^1, R^2, R^3, R^4, R^5, and R^6 are each independently a hydrogen atom, a halogen atom, a methyl group that may or may not be substituted with fluorine, an ethyl group that may or may not be substituted with fluorine, a straight, branched or cyclic alkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic heteroalkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, an alkoxyl group that has 1 to 18 carbon atoms and may or may not be substituted with fluorine, an aryl group that has 5 to 20 carbon atoms and may or may not be substituted with fluorine, an aralkyl group that has 5 to 35 carbon atoms and may or may not be substituted with fluorine, or a heteroaralkyl group that has 5 to 35 carbon atoms and may or may not be substituted with fluorine;

with the proviso that at least one of R^1, R^2, R^3, R^4, R^5 and R^6 is a substituent represented by the following formula (2b):



(2b)

(wherein Pf is a straight, branched or cyclic alkyl group that has 2 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aryl group that has 5 to 20 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, or a heteroaralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, and n is an integer from 0 to 4.) and/or by the following formula (2c):



(2c)

(wherein Pf and n are as defined in the formula (2b) above, R^{13}

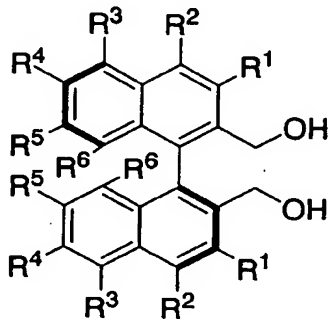
and R^{14} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms.); X is a chlorine atom, a bromine atom, an iodine atom, or a p-toluenesulfonyloxy group; and the binaphthyl moiety has a chiral axis so that the absolute configuration of the binaphthyl moiety is (R) or (S)].

13. The optically active binaphthyl compound according to claim 12, wherein R^1, R^3, R^5, and R^6 in the formula (3b) are each independently a hydrogen atom; and R^2 and R^4 are identical to one another and are each represented by the formula (2c).

14. The optically active binaphthyl compound according to claim 12, wherein in the formula (3b), R^1, R^3, R^5, and R^6 are each independently a hydrogen atom, R^2 and R^4 are identical to one another and are each represented by the formula (2c), and X is a bromine atom; and in the formula (2c), n is 2, R^{13} and R^{14} are each a methyl group, and Pf is an n-octyl group having all the hydrogen atoms substituted with fluorine atoms.

15. A method for producing the optically active quaternary ammonium salt according to any of claims 1 to 8 represented by the formula (1a) or (1b) in which X^- is a chloride ion, a bromide ion, a iodide ion, or a p-toluenesulfonic acid ion, characterized in that the optically active binaphthyl compound according to any of claims 9 to 14 represented by the formula (3a) or (3b) is reacted with ammonia.

16. An optically active binaphthyl dihydroxyl compound represented by the following formula (4a):

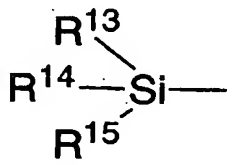


(4a)

[wherein R^1, R^2, R^3, R^4, R^5, and R^6 are each independently a hydrogen atom, a methyl group, an ethyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic heteroalkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20

carbon atoms, an aralkyl group having 5 to 35 carbon atoms, or a heteroaralkyl group having 5 to 35 carbon atoms;

with the proviso that at least one of R^1, R^2, R^3, R^4, R^5, and R^6 is a substituent represented by the following formula (2a):



(2a)

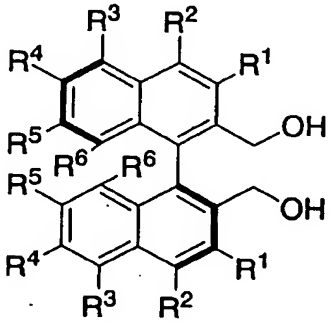
(wherein R^{13}, R^{14}, and R^{15} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms); and the binaphthyl moiety has a chiral axis so that the absolute configuration of the binaphthyl moiety is (R) or (S)].

17. The optically active binaphthyl dihydroxyl compound according to claim 16, wherein R^1, R^3, R^5, and R^6 in the formula (4a) are each independently a hydrogen atom; and R^2 and R^4 are identical to one another and are each represented by the

formula (2a).

18. The optically active binaphthyl dihydroxyl compound according to claim 16, wherein in the formula (4a), R^1, R^3, R^5, and R^6 are each independently a hydrogen atom, and R^2 and R^4 are identical to one another and are each represented by the formula (2a); and R^{13}, R^{14}, and R^{15} in the formula (2a) are each independently a substituent selected from the group consisting of a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-octyl group, and a phenyl group.

19. An optically active binaphthyl dihydroxyl compound represented by the following formula (4b):

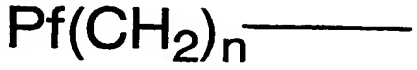


(4b)

[wherein R^1, R^2, R^3, R^4, R^5, and R^6 are each independently a hydrogen atom, a halogen atom, a methyl group that may or may not be substituted with fluorine, an ethyl group that may or may not be substituted with fluorine, a straight, branched or

cyclic alkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic heteroalkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, an alkoxyl group that has 1 to 18 carbon atoms and may or may not be substituted with fluorine, an aryl group that has 5 to 20 carbon atoms and may or may not be substituted with fluorine, an aralkyl group that has 5 to 35 carbon atoms and may or may not be substituted with fluorine, or a heteroaralkyl group that has 5 to 35 carbon atoms and may or may not be substituted with fluorine;

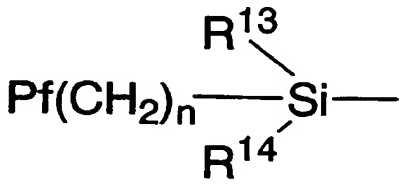
with the proviso that at least one of R^1, R^2, R^3, R^4, R^5 and R^6 is a substituent represented by the following formula (2b):



(2b)

(wherein Pf is a straight, branched or cyclic alkyl group that has 2 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and has all

the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aryl group that has 5 to 20 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, or a heteroaralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, and n is an integer from 0 to 4.), and/or by the following formula (2c):



(2c)

(wherein Pf and n are as defined in the formula (2b) above,

R^{13} and R^{14} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms.); and the binaphthyl moiety has a chiral axis so that the absolute configuration of the binaphthyl

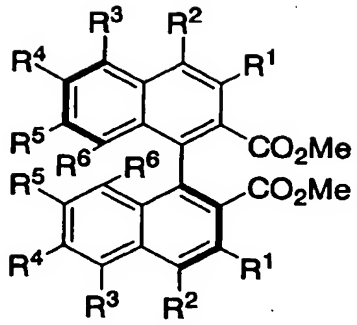
moiety is (R) or (S)].

20. The optically active binaphthyl dihydroxyl compound according to claim 19, wherein R^1, R^3, R^5, and R^6 in the formula (4b) are each independently a hydrogen atom; and R^2 and R^4 are identical to one another and are each represented by the formula (2c).

21. The optically active binaphthyl dihydroxyl compound according to claim 19, wherein in the formula (4b), R^1, R^3, R^5, and R^6 are each independently a hydrogen atom, and R^2 and R^4 are identical to one another and are each represented by the formula (2c); and in the formula (2c), n is 2, R^{13} and R^{14} are each a methyl group, and Pf is an n-octyl group having all the hydrogen atoms substituted with fluorine atoms.

22. A method for producing the optically active binaphthyl compound of the formula (3a) or (3b) according to any of claims 9 to 14, characterized in that the optically active binaphthyl dihydroxyl compound of the formula (4a) or (4b) according to any of claims 16 to 21 is reacted with a halogen source or p-toluenesulfonyl chloride.

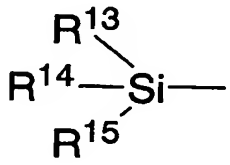
23. An optically active binaphthyl diester compound represented by the following formula (5a):



(5 a)

[wherein R^1, R^2, R^3, R^4, R^5, and R^6 are each independently a hydrogen atom, a methyl group, an ethyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic heteroalkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 35 carbon atoms, or a heteroaralkyl group having 5 to 35 carbon atoms;

with the proviso that at least one of R^1, R^2, R^3, R^4, R^5 and R^6 is a substituent represented by the following formula (2a):



(2 a)

(wherein R^{13}, R^{14}, and R^{15} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic

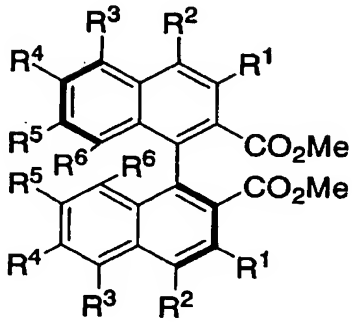
alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms); and the binaphthyl moiety has a chiral axis so that the absolute configuration of the binaphthyl moiety is (R) or (S)].

24. The optically active binaphthyl diester compound according to claim 23, wherein R^1, R^3, R^5, and R^6 in the formula (3a) are each independently a hydrogen atom; and R^2 and R^4 are identical to one another and are each represented by the formula (2a).

25. The optically active binaphthyl diester compound according to claim 23, wherein in the formula (5a), R^1, R^3, R^5, and R^6 are each independently a hydrogen atom, R^2 and R^4 are identical to one another and are each represented by the formula (2a), and R^{13}, R^{14}, and R^{15} in the formula (2a) are each independently a substituent selected from the group consisting of a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-octyl group, and a

phenyl group.

26. An optically active binaphthyl diester compound represented by the following formula (5b):

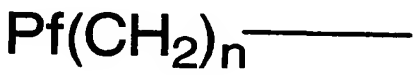


(5b)

[wherein R^1, R^2, R^3, R^4, R^5, and R^6 are each independently a hydrogen atom, a halogen atom, a methyl group that may or may not be substituted with fluorine, an ethyl group that may or may not be substituted with fluorine, a straight, branched or cyclic alkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic heteroalkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, an alkoxyl group that has 1 to 18 carbon atoms and may or may not be substituted with fluorine, an aryl group that has 5 to 20 carbon atoms and may or may not be substituted with fluorine, an aralkyl group

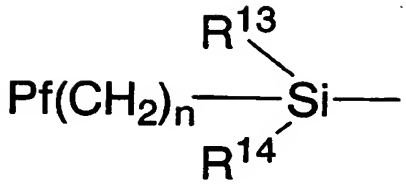
that has 5 to 35 carbon atoms and may or may not be substituted with fluorine, or a heteroaralkyl group that has 5 to 35 carbon atoms and may or may not be substituted with fluorine;

with the proviso that at least one of R^1, R^2, R^3, R^4, R^5 and R^6 is a substituent represented by the following formula (2b):



(2b)

(wherein Pf is a straight, branched or cyclic alkyl group that has 2 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aryl group that has 5 to 20 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, or a heteroaralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, and n is an integer from 0 to 4.) and/or by the following formula (2c):



(2c)

(wherein Pf and n are as defined in the formula (2b) above,

R^{13} and R^{14} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms.); and the binaphthyl moiety has a chiral axis so that the absolute configuration of the binaphthyl moiety is (R) or (S)].

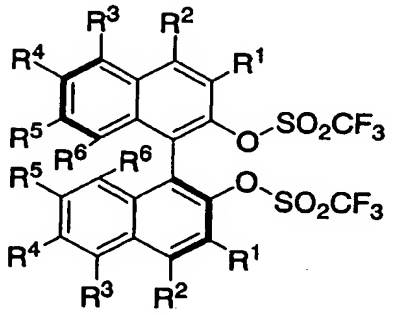
27. The optically active binaphthyl diester compound according to claim 26, wherein R^1, R^3, R^5, and R^6 in the formula (5b) are each independently a hydrogen atom; and R^2 and R^4 are identical to one another and are each represented by the formula (2c).

28. The optically active binaphthyl diester compound according to claim 26, wherein in the formula (5b), R^1, R^3, R^5,

and R^6 are each independently a hydrogen atom, and R^2 and R^4 are identical to one another and are each represented by the formula (2c); and in the formula (2c), n is 2, R^{13} and R^{14} are each a methyl group, and Pf is an n-octyl group having all the hydrogen atoms substituted with fluorine atoms.

29. A method for producing the compound according to any of claims 16 to 21 represented by the formula (4a) or (4b), characterized in that the optically active binaphthyl diester compound according to any of claims 23 to 28 represented by the formula (5a) or (5b) is reacted with hydrogen anion.

30. An optically active binaphthyl compound represented by the following formula (6a):

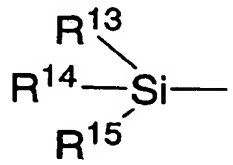


(6a)

[wherein R^1, R^2, R^3, R^4, R^5, and R^6 are each independently a hydrogen atom, a methyl group, an ethyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic heteroalkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group

having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 35 carbon atoms, or a heteroaralkyl group having 5 to 35 carbon atoms;

with the proviso that at least one of R^1, R^2, R^3, R^4, R^5, and R^6 is a substituent represented by the following formula (2a):



(2a)

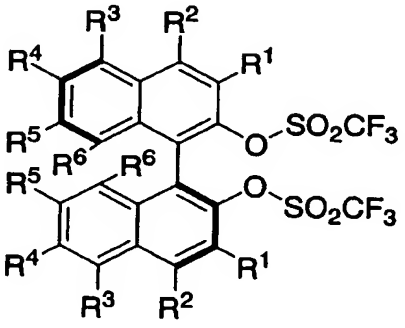
(wherein R^{13}, R^{14}, and R^{15} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms); and the binaphthyl moiety has a chiral axis so that the absolute configuration of the binaphthyl moiety is (R) or (S)].

31. The optically active binaphthyl compound according to

claim 30, wherein R^1, R^3, R^5, and R^6 in the formula (6a) are each independently a hydrogen atom; and R^2 and R^4 are identical to one another and are each represented by the formula (2a).

32. The optically active binaphthyl compound according to claim 30, wherein in the formula (6a), R^1, R^3, R^5, and R^6 are each independently a hydrogen atom, and R^2 and R^4 are identical to one another and are each represented by the formula (2a); and R^{13}, R^{14}, and R^{15} in the formula (2a) are each independently a substituent selected from the group consisting of a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-octyl group, and a phenyl group.

33. An optically active binaphthyl compound represented by the following formula (6b):

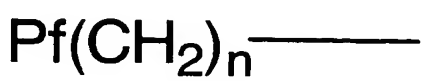


(6 b)

[wherein R^1, R^2, R^3, R^4, R^5, and R^6 are each independently a hydrogen atom, a halogen atom, a methyl group that may or may not be substituted with fluorine, an ethyl group that may or

may not be substituted with fluorine, a straight, branched or cyclic alkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic heteroalkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, an alkoxyl group that has 1 to 18 carbon atoms and may or may not be substituted with fluorine, an aryl group that has 5 to 20 carbon atoms and may or may not be substituted with fluorine, an aralkyl group that has 5 to 35 carbon atoms and may or may not be substituted with fluorine, or a heteroaralkyl group that has 5 to 35 carbon atoms and may or may not be substituted with fluorine;

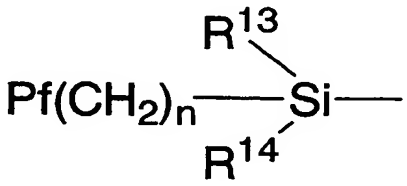
with the proviso that at least one of R^1, R^2, R^3, R^4, R^5 and R^6 is a substituent represented by the following formula (2b):



(2b)

(wherein Pf is a straight, branched or cyclic alkyl group that has 2 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or

cyclic alkenyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aryl group that has 5 to 20 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, or a heteroaralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, and n is an integer from 0 to 4.), and/or by the following formula (2c):



(2c)

(wherein Pf and n are as defined in the formula (2b) above,

R^{13} and R^{14} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms.); and the binaphthyl moiety has a chiral

axis so that the absolute configuration of the binaphthyl moiety is (R) or (S)].

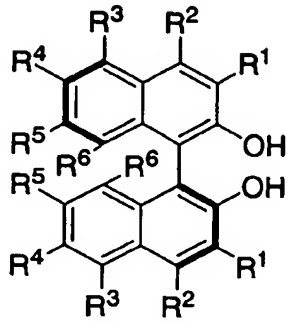
34. The optically active binaphthyl compound according to claim 33, wherein R^1, R^3, R^5, and R^6 in the formula (6b) are each independently a hydrogen atom; and R^2 and R^4 are identical to one another and are each represented by the formula (2c).

35. The optically active binaphthyl compound according to claim 33, wherein in the formula (6b), R^1, R^3, R^5, and R^6 are each independently a hydrogen atom, and R^2 and R^4 are identical to one another and are each represented by the formula (2c); and in the formula (2c), n is 2, R^{13} and R^{14} are each a methyl group, and Pf is an n-octyl group having all the hydrogen atoms substituted with fluorine atoms.

36. A method for producing the optically active binaphthyl diester compound of the formula (5a) or (5b) according to any of claims 23 to 28, characterized in that the optically active binaphthyl compound of the formula (6a) or (6b) according to any of claims 30 to 35 is reacted with carbon monoxide and methanol in the presence of a palladium catalyst and an organic base.

37. An optically active binaphthol compound represented by

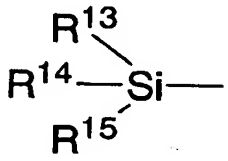
the following formula (7a):



(7a)

[wherein R^1, R^2, R^3, R^4, R^5, and R^6 are each independently a hydrogen atom, a methyl group, an ethyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic heteroalkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 35 carbon atoms, or a heteroaralkyl group having 5 to 35 carbon atoms;

with the proviso that at least one of R^1, R^2, R^3, R^4, R^5 and R^6 is a substituent represented by the following formula (2a):



(2a)

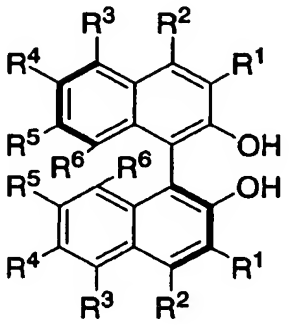
(wherein R^{13}, R^{14}, and R^{15} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic

alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms); and the binaphthyl moiety has a chiral axis so that the absolute configuration of the binaphthyl moiety is (R) or (S)].

38. The optically active binaphthol compound according to claim 37, wherein R^1, R^3, R^5, and R^6 in the formula (7a) are each independently a hydrogen atom; and R^2 and R^4 are identical to one another and are each represented by the formula (2a).

39. The optically active binaphthol compound according to claim 37, wherein in the formula (7a), R^1, R^3, R^5, and R^6 are each independently a hydrogen atom, R^2 and R^4 are identical to one another and are each represented by the formula (2a), and R^{13}, R^{14} and R^{15} in the formula (2a) are each independently a substituent selected from the group consisting of a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-octyl group, and a phenyl group.

40. An optically active binaphthol compound represented by the following formula (7b):

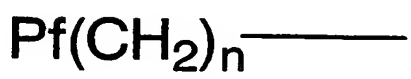


(7b)

[wherein R^1, R^2, R^3, R^4, R^5, and R^6 are each independently a hydrogen atom, a halogen atom, a methyl group that may or may not be substituted with fluorine, an ethyl group that may or may not be substituted with fluorine, a straight, branched or cyclic alkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic heteroalkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, an alkoxyl group that has 1 to 18 carbon atoms and may or may not be substituted with fluorine, an aryl group that has 5 to 20 carbon atoms and may or may not be substituted with fluorine, an aralkyl group that has 5 to 35 carbon atoms and may or may not be substituted with fluorine, or a heteroaralkyl group that has 5

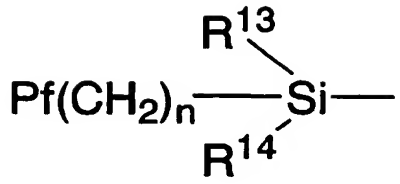
to 35 carbon atoms and may or may not be substituted with fluorine;

with the proviso that at least one of R^1, R^2, R^3, R^4, R^5 and R^6 is a substituent represented by the following formula (2b):



(2b)

(wherein Pf is a straight, branched or cyclic alkyl group that has 2 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aryl group that has 5 to 20 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, or a heteroaralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, and n is an integer from 0 to 4.) and/or by the following formula (2c):



(2c)

(wherein Pf and n are as defined in the formula (2b) above, R^{13} and R^{14} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms.); and the binaphthyl moiety has a chiral axis so that the absolute configuration of the binaphthyl moiety is (R) or (S)].

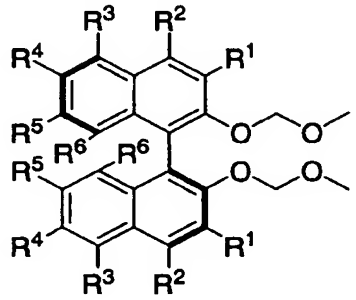
41. The optically active binaphthol compound according to claim 40, wherein R^1, R^3, R^5, and R^6 in the formula (7b) are each independently a hydrogen atom; and R^2 and R^4 are identical to one another and are each represented by the formula (2c).

42. The optically active binaphthol compound according to claim 40, wherein in the formula (7b), R^1, R^3, R^5, and R^6 are each independently a hydrogen atom, and R^2 and R^4 are identical

to one another and are each represented by the formula (2c); and in the formula (2c), n is 2, R^{13} and R^{14} are each a methyl group, and Pf is an n-octyl group having all the hydrogen atoms substituted with fluorine atoms.

43. A method for producing the optically active binaphthyl compound according to any of claim 30 to 35 represented by the formula (6a) or (6b), characterized in that the optically active binaphthol compound according to any of claims 37 to 42 represented by the formula (7a) or (7b) is reacted with a triflating agent.

44. An optically active binaphthyl bis-methoxymethyl ether compound represented by the following formula (8a):

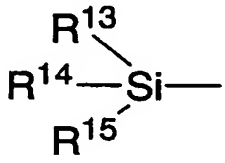


(8 a)

[wherein R^1, R^2, R^3, R^4, R^5, and R^6 are each independently a hydrogen atom, a methyl group, an ethyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic heteroalkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group

having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 35 carbon atoms, or a heteroaralkyl group having 5 to 35 carbon atoms;

with the proviso that at least one of R^1, R^2, R^3, R^4, R^5, and R^6 is a substituent represented by the following formula (2a):



(2a)

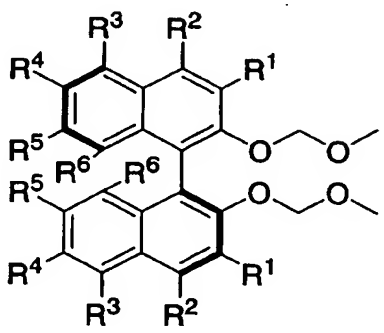
(wherein R^{13}, R^{14}, and R^{15} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms); and the binaphthyl moiety has a chiral axis so that the absolute configuration of the binaphthyl moiety is (R) or (S)].

45. The optically active binaphthyl bis-methoxymethyl ether

compound according to claim 44, wherein R^1, R^3, R^5, and R^6 in the formula (8a) are each independently a hydrogen atom; and R^2 and R^4 are identical to one another and are each represented by the formula (2a).

46. The optically active binaphthyl bis-methoxymethyl ether compound according to claim 44, wherein in the formula (8a), R^1, R^3, R^5, and R^6 are each independently a hydrogen atom, R^2 and R^4 are identical to one another and are each represented by the formula (2a), and R^{13}, R^{14}, and R^{15} in the formula (2a) are each independently a substituent selected from the group consisting of a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-octyl group, and a phenyl group.

47. An optically active binaphthyl bis-methoxymethyl ether compound represented by the following formula (8b):

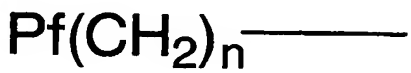


(8b)

[wherein R^1, R^2, R^3, R^4, R^5, and R^6 are each independently a

hydrogen atom, a halogen atom, a methyl group that may or may not be substituted with fluorine, an ethyl group that may or may not be substituted with fluorine, a straight, branched or cyclic alkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic heteroalkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, an alkoxyl group that has 1 to 18 carbon atoms and may or may not be substituted with fluorine, an aryl group that has 5 to 20 carbon atoms and may or may not be substituted with fluorine, an aralkyl group that has 5 to 35 carbon atoms and may or may not be substituted with fluorine, or a heteroaralkyl group that has 5 to 35 carbon atoms and may or may not be substituted with fluorine;

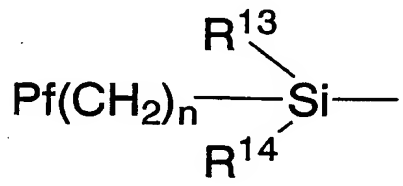
with the proviso that at least one of R^1, R^2, R^3, R^4, R^5 and R^6 is a substituent represented by the following formula (2b):



(2b)

(wherein Pf is a straight, branched or cyclic alkyl group that

has 2 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aryl group that has 5 to 20 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, or a heteroaralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, and n is an integer from 0 to 4.) and/or by the following formula (2c):



(2c)

(wherein Pf and n are as defined in the formula (2b) above, R^{13} and R^{14} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25

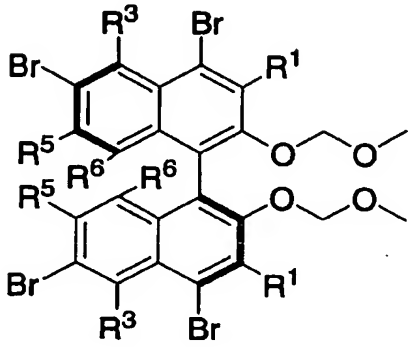
carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms.); and the binaphthyl moiety has a chiral axis so that the absolute configuration of the binaphthyl moiety is (R) or (S)].

48. The optically active binaphthyl bis-methoxymethyl ether compound according to claim 47, wherein R^1, R^3, R^5, and R^6 in the formula (8b) are each independently a hydrogen atom; and R^2 and R^4 are identical to one another and are each represented by the formula (2c).

49. The optically active binaphthyl bis-methoxymethyl ether compound according to claim 47, wherein in the formula (8b), R^1, R^3, R^5, and R^6 are each independently a hydrogen atom, and R^2 and R^4 are identical to one another and are each represented by the formula (2c); and in the formula (2c), n is 2, R^{13} and R^{14} are each a methyl group, and Pf is an n-octyl group having all the hydrogen atoms substituted with fluorine atoms.

50. A method for producing the optically active binaphthol compound according to any of claims 37 to 42 represented by the formula (7a) or (7b), characterized in that the optically active binaphthyl bis-methoxymethyl ether compound according to any of claims 44 to 49 represented by the formula (8a) or (8b) is reacted with an acid.

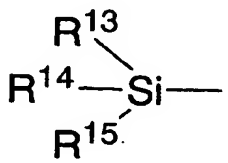
51. An optically active binaphthyl bis-methoxymethyl ether compound represented by the following formula (9a):



(9a)

[wherein R^1, R^2, R^3, R^4, R^5, and R^6 are each independently a hydrogen atom, a methyl group, an ethyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic heteroalkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 35 carbon atoms, or a heteroaralkyl group having 5 to 35 carbon atoms;

with the proviso that at least one of R^1, R^2, R^3, R^4, R^5, and R^6 is a substituent represented by the following formula (2a):

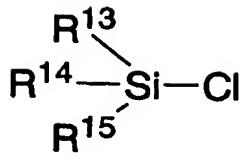


(2a)

(wherein R^{13}, R^{14}, and R^{15} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms); and the binaphthyl moiety has a chiral axis so that the absolute configuration of the binaphthyl moiety is (R) or (S)].

52. The optically active binaphthyl bis-methoxymethyl ether compound according to claim 51, wherein R^1, R^3, R^5, and R^6 in the formula (9a) are each independently hydrogen.

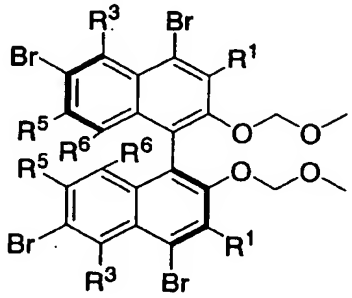
53. A method for producing the optically active binaphthyl bis-methoxymethyl ether compound according to any of claims 44 to 46 represented by the formula (8a), comprising reacting with an alkyl lithium the optically active binaphthyl bis-methoxymethyl ether compound according to any of claim 51 or 52 represented by the formula (9a), and subsequently reacting with the reaction product a silyl chloride represented by the following formula (10a):



(10a)

(wherein R^{13}, R^{14}, and R^{15} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms).

54. A method for producing the optically active binaphthyl bis-methoxymethyl ether compound according to any of claims 47 to 49 represented by the formula (8b), comprising reacting with an alkyl lithium an optically active binaphthyl bis-methoxymethyl ether compound represented by the following formula (9b):

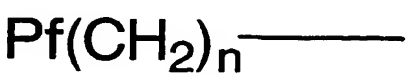


(9b)

[wherein R^1, R^2, R^3, R^4, R^5, and R^6 are each independently a

hydrogen atom, a halogen atom, a methyl group that may or may not be substituted with fluorine, an ethyl group that may or may not be substituted with fluorine, a straight, branched or cyclic alkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic heteroalkyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and may or may not be substituted with fluorine, an alkoxyl group that has 1 to 18 carbon atoms and may or may not be substituted with fluorine, an aryl group that has 5 to 20 carbon atoms and may or may not be substituted with fluorine, an aralkyl group that has 5 to 35 carbon atoms and may or may not be substituted with fluorine, or a heteroaralkyl group that has 5 to 35 carbon atoms and may or may not be substituted with fluorine;

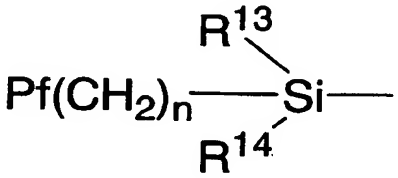
with the proviso that at least one of R^1, R^2, R^3, R^4, R^5, and R^6 is a substituent represented by the following formula (2b):



(2b)

(wherein Pf is a straight, branched or cyclic alkyl group that has 2 to 18 carbon atoms and has all the hydrogen atoms

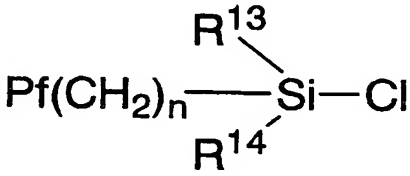
substituted with fluorine atoms, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aryl group that has 5 to 20 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, or a heteroaralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, and n is an integer from 0 to 4.) and/or by the following formula (2c):



(2c)

(wherein Pf and n are as defined in the formula (2b) above, R^{13} and R^{14} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, a heteroaralkyl group having 5 to 25 carbon

atoms, or a substituent represented by the formula (2b)); and the binaphthyl moiety has a chiral axis so that the absolute configuration of the binaphthyl moiety is (R) or (S).], and subsequently reacting with the reaction product a compound represented by the following formula (10c):

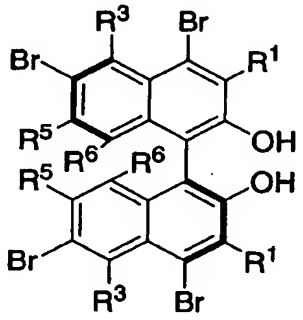


(10c)

[wherein Pf is a straight, branched or cyclic alkyl group that has 2 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkenyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a straight, branched or cyclic alkynyl group that has 3 to 18 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aryl group that has 5 to 20 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, an aralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, a heteroaralkyl group that has 5 to 25 carbon atoms and has all the hydrogen atoms substituted with fluorine atoms, n is an integer from 0 to 4, and R^{13} and R^{14} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or

cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, a heteroaralkyl group having 5 to 25 carbon atoms, or a substituent represented by the formula (2b).]

55. A method for producing the optically active binaphthyl bis-methoxymethyl ether compound according to any of claim 51 or 52 represented by the formula (9a), comprising forming a binaphthoxide from an optically active binaphthol compound represented by the following formula (11a) in the presence of an acid-capturing agent or by treatment with a base:

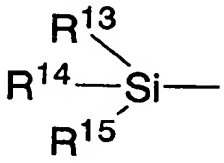


(11a)

[wherein R^1, R^2, R^3, R^4, R^5, and R^6 are each independently a hydrogen atom, a methyl group, an ethyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic heteroalkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group

having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 35 carbon atoms, or a heteroaralkyl group having 5 to 35 carbon atoms;

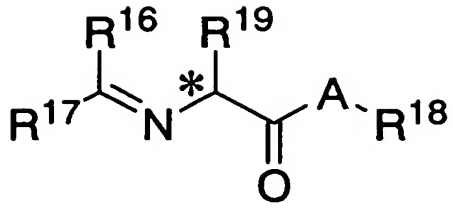
with the proviso that at least one of R^1, R^2, R^3, R^4, R^5, and R^6 is a substituent represented by the following formula (2a):



(2a)

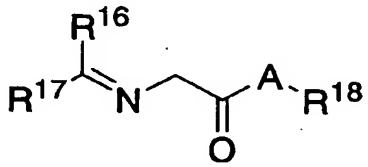
(wherein R^{13}, R^{14}, and R^{15} are each independently a methyl group, an ethyl group, a vinyl group, a straight, branched or cyclic alkyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkenyl group having 3 to 18 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 18 carbon atoms, an alkoxyl group having 1 to 18 carbon atoms, an aryl group having 5 to 20 carbon atoms, an aralkyl group having 5 to 25 carbon atoms, or a heteroaralkyl group having 5 to 25 carbon atoms); and the binaphthyl moiety has a chiral axis so that the absolute configuration of the binaphthyl moiety is (R) or (S).], and subsequently reacting the binaphthoxide with chloromethyl ether.

56. A method for stereoselectively producing a compound represented by the following formula (14):



(14)

[wherein R^{16}, R^{17}, R^{18}, R^{19}, and A are as defined above, and the chiral carbon indicated by an asterisk '*' has an absolute configuration of (R) or (S)], comprising reacting, in a two-phase solution, a Schiff base of a glycine ester or an amide represented by the following formula (12):



(12)

[wherein R^{16} and R^{17} are each independently a hydrogen atom or an aryl group that has 5 to 10 carbon atoms and may or may not be substituted with halogen,

with the proviso that R^{16} and R^{17} are not a hydrogen atom at the same time; R^{18} is a straight, branched or cyclic alkyl group having 1 to 6 carbon atoms; and A is an oxygen atom or a nitrogen atom having a single hydrogen atom bound thereto] with an alkyl halide represented by the following formula (13):

(13)

[wherein R^{19} is a straight, branched or cyclic alkyl group having 1 to 10 carbon atoms, a straight, branched or cyclic

alkenyl group having 3 to 10 carbon atoms, a straight, branched or cyclic alkynyl group having 3 to 10 carbon atoms, or an aralkyl group that has 5 to 25 carbon atoms and may or may not have its nucleus substituted with 1 to 15 halogen atoms; and Y is a chlorine atom, a bromine atom, or an iodine atom] in the presence of an optically active quaternary ammonium salt according to [1] to [8] above represented by the formula (1a) or (1b) and an inorganic base.

57. The method according to claim 56, wherein the reaction is carried out in a three-phase solution comprising an organic solvent with hydrogen atoms substituted with fluorine atoms, an organic solvent, and water.

58. A method for recovering an optically active quaternary ammonium salt, characterized in that an organic solvent, water, a mixed solvent of an organic solvent and water, and/or an organic solvent with hydrogen atoms substituted with fluorine atoms are/is used to separate the optically active quaternary ammonium salt according to any of claims 5 to 8 represented by the formula (1b) from a product containing the ammonium salt.

59. A method for recovering the optically active quaternary ammonium salt according to any of claims 5 to 8 represented by the formula (1b), characterized in that, following the

production of the compound of the formula (14) by the method according to claim 56, which is carried out in the presence of the optically active quaternary ammonium salt of the formula (1b), the ammonium salt is separated from the reaction mixture containing the optically active quaternary ammonium salt by using an organic solvent, water, a mixed solvent of an organic solvent and water, and/or an organic solvent with hydrogen atoms substituted with fluorine atoms.

60. The method according to claim 59, wherein hexane with its hydrogen atoms substituted with fluorine atoms is used as the fluorine-substituted organic solvent.